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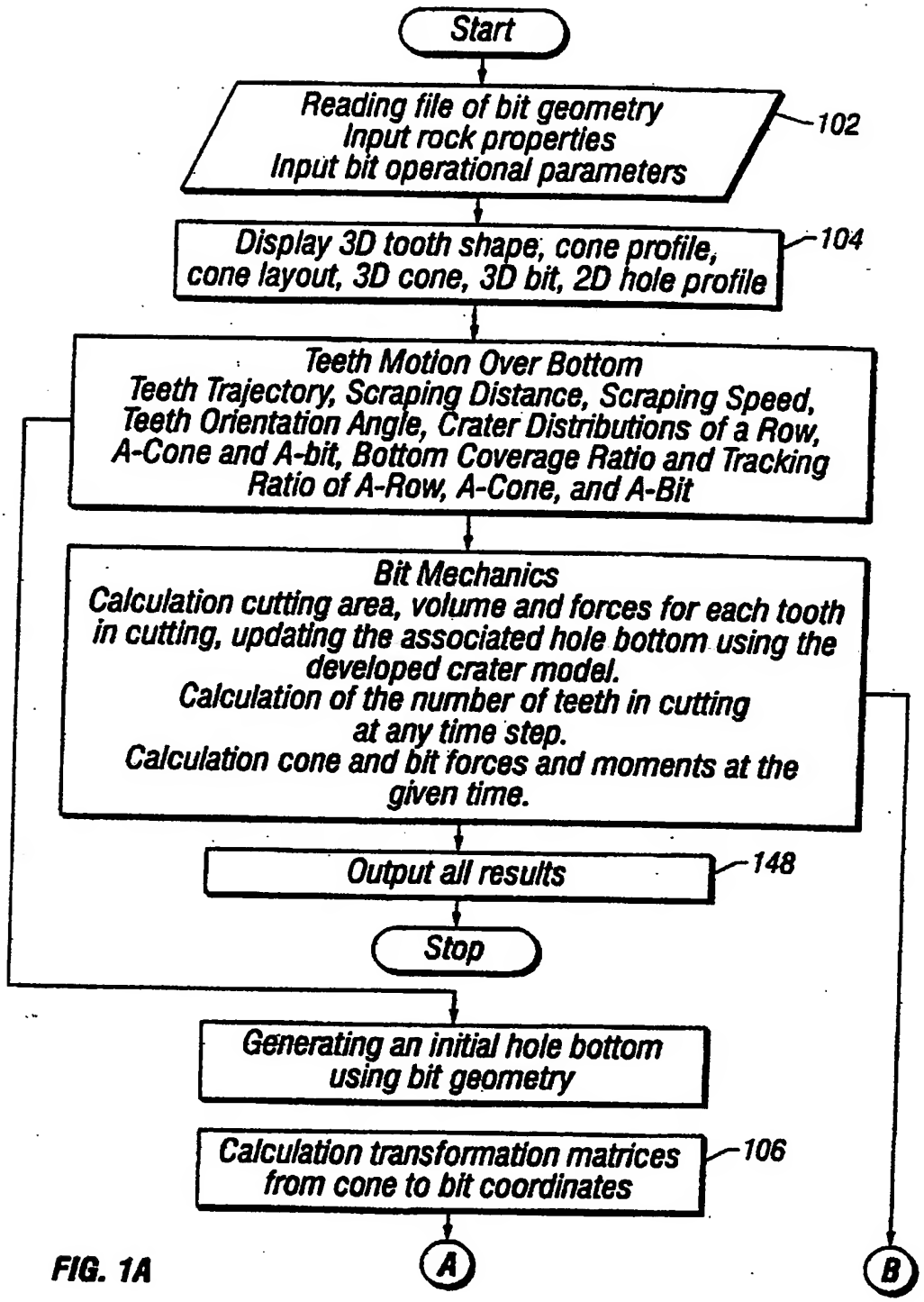
Start
Reading file of bit geometry
Input rock properties
Input bit operational parameters
102
Display 3D tooth shape, cone profile, cone layout, 3D cone, 3D bit, 2D hole profile
104
Teeth Motion Over Bottom
Teeth Trajectory, Scraping Distance, Scraping Speed, Teeth Orientation Angle, Crater Distributions of a Row, A-Cone and A-bit, Bottom Coverage Ratio and Tracking Ratio of A-Row, A-Cone, and A-Bit
Bit Mechanics
Calculation cutting area, volume and forces for each tooth in cutting, updating the associated hole bottom using the developed crater model.
Calculation of the number of teeth in cutting at any time step.
Calculation cone and bit forces and moments at the given time.
Output all results
148
Stop
Generating an initial hole bottom using bit geometry
Calculation transformation matrices from cone to bit coordinates
106
A
B

FIG. 1A

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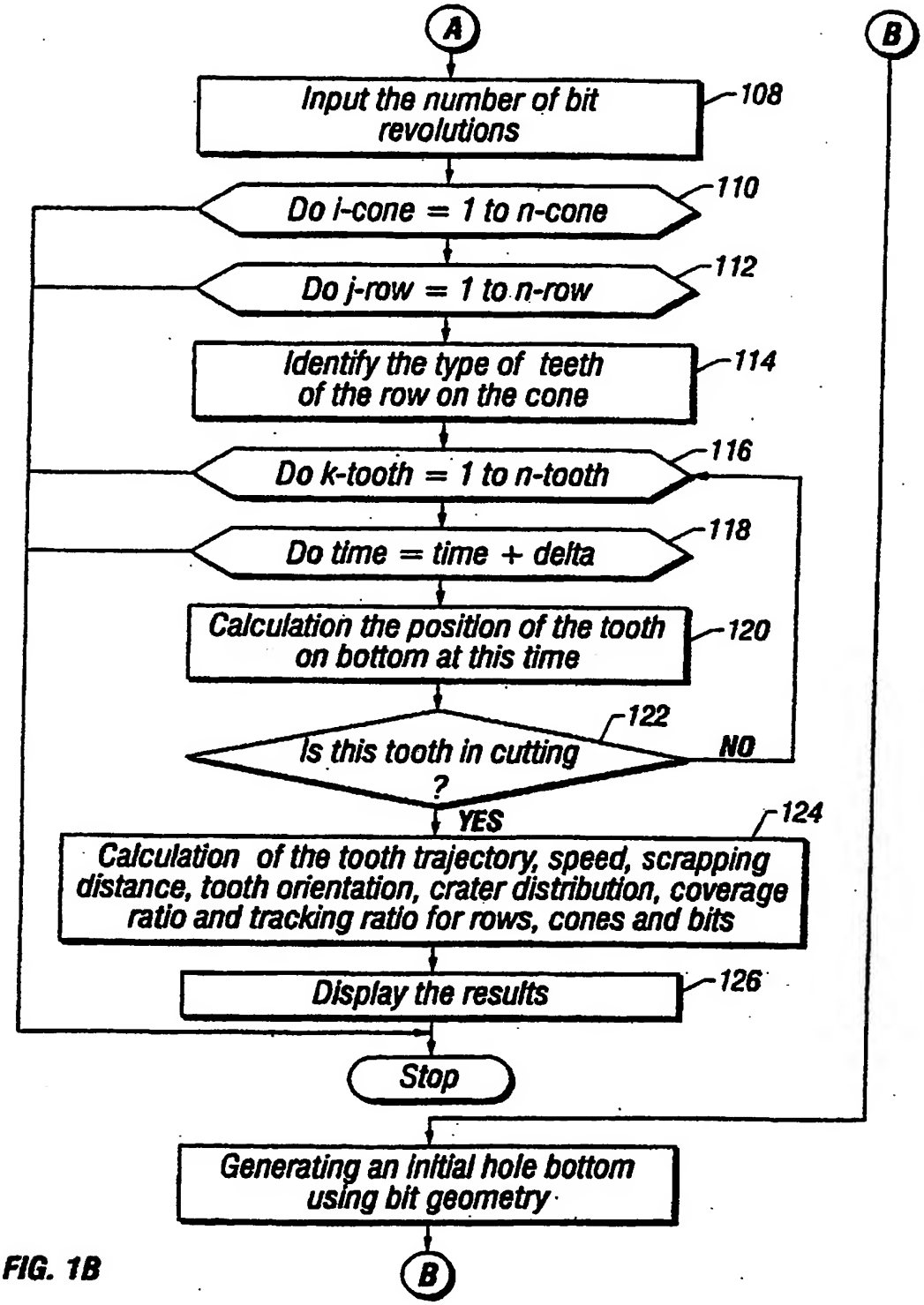
A
B
Input the number of bit revolutions
108
Do i-cone = 1 to n-cone
110
Do j-row = 1 to n-row
112
Identify the type of teeth of the row on the cone
114
Do k-tooth = 1 to n-tooth
116
Do time = time + delta
118
Calculation the position of the tooth on bottom at this time
120
Is this tooth in cutting ?
122
NO
YES
Calculation of the tooth trajectory, speed, scrapping distance, tooth orientation, crater distribution, coverage ratio and tracking ratio for rows, cones and bits
124
Display the results
126
Stop
Generating an initial hole bottom using bit geometry
B

FIG. 1B

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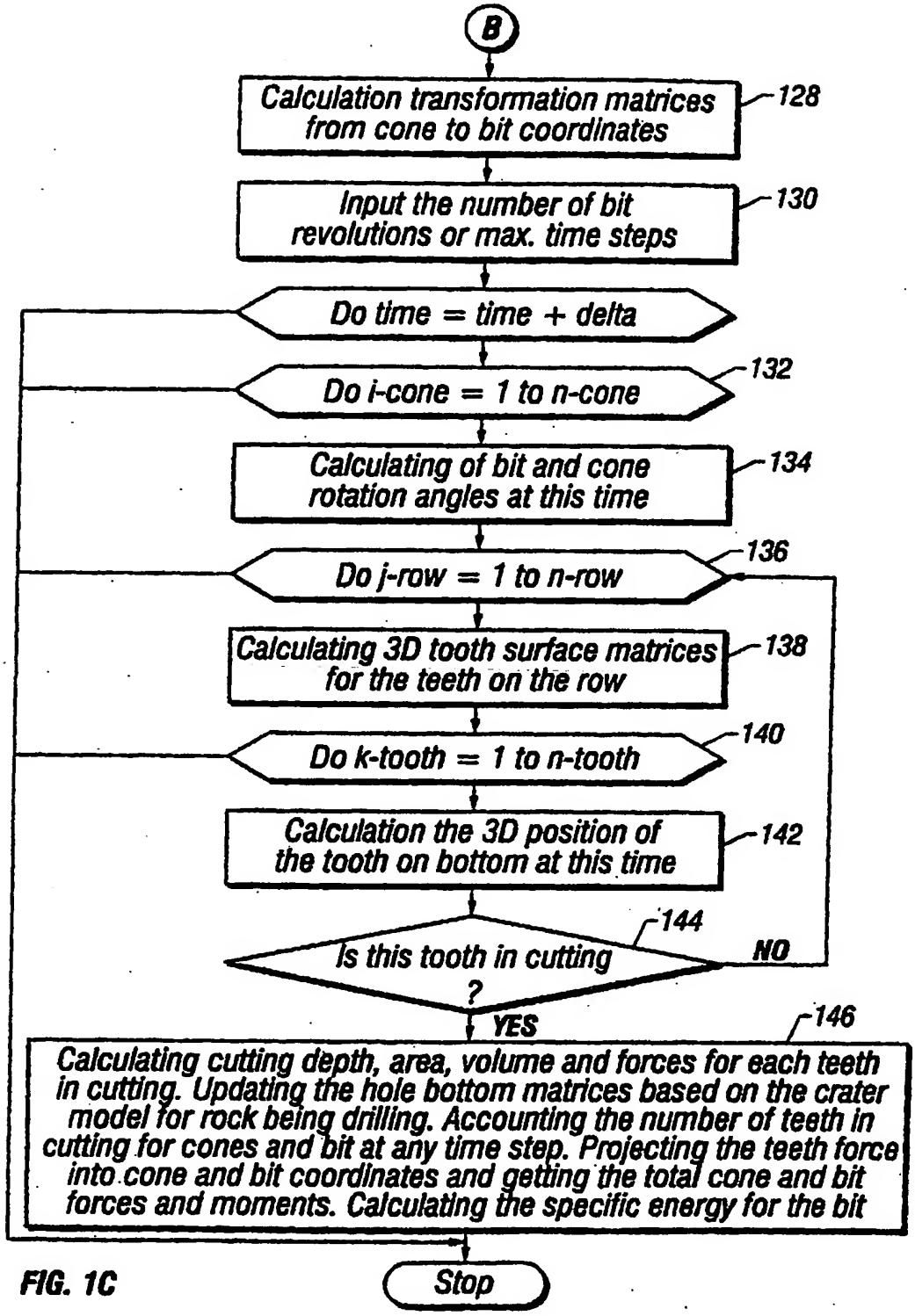
B
Calculation transformation matrices from cone to bit coordinates
128
Input the number of bit revolutions or max. time steps
130
Do time = time + delta
Do i-cone = 1 to n-cone
132
Calculating of bit and cone rotation angles at this time
134
Do j-row = 1 to n-row
136
Calculating 3D tooth surface matrices for the teeth on the row
138
Do k-tooth = 1 to n-tooth
140
Calculation the 3D position of the tooth on bottom at this time
142
Is this tooth in cutting ?
144
NO
YES
146
Calculating cutting depth, area, volume and forces for each teeth in cutting. Updating the hole bottom matrices based on the crater model for rock being drilling. Accounting the number of teeth in cutting for cones and bit at any time step. Projecting the teeth force into cone and bit coordinates and getting the total cone and bit forces and moments. Calculating the specific energy for the bit
Stop

FIG. 1C

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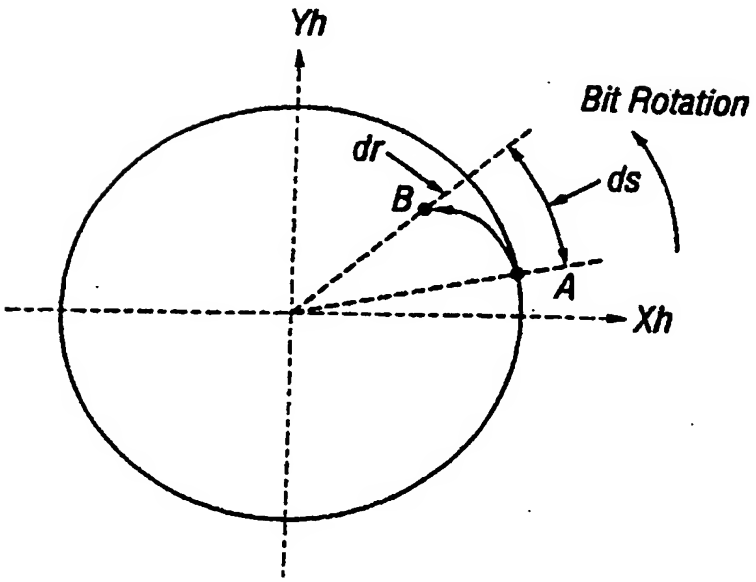

FIG. 2

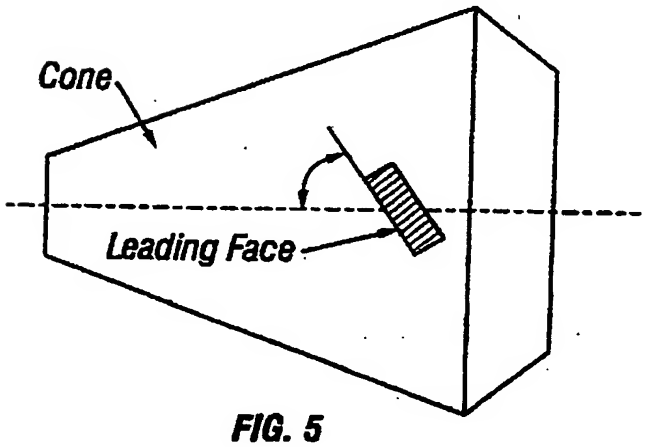

FIG. 5

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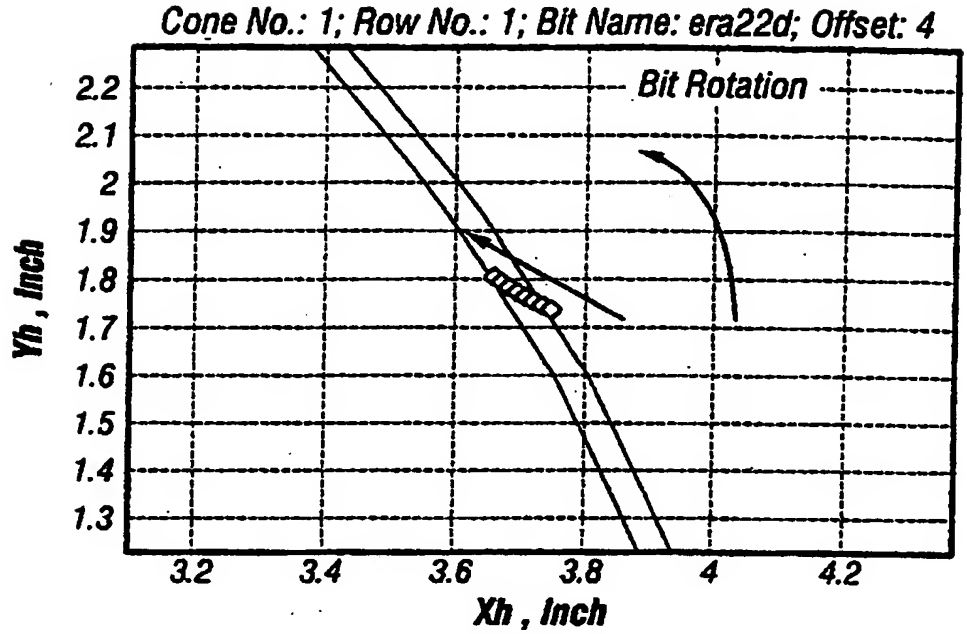

FIG. 3A

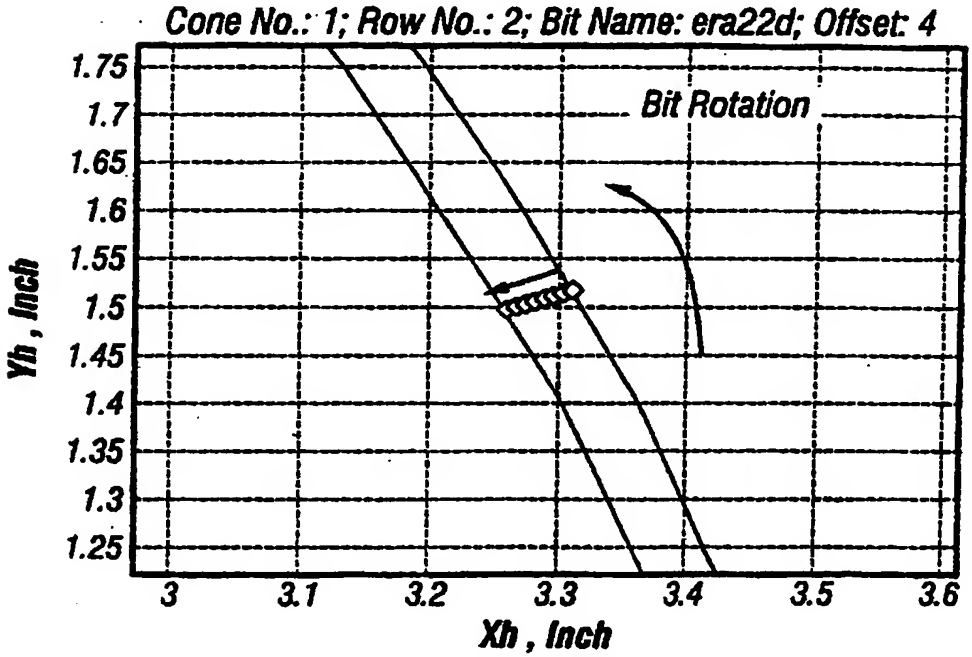

FIG. 3B

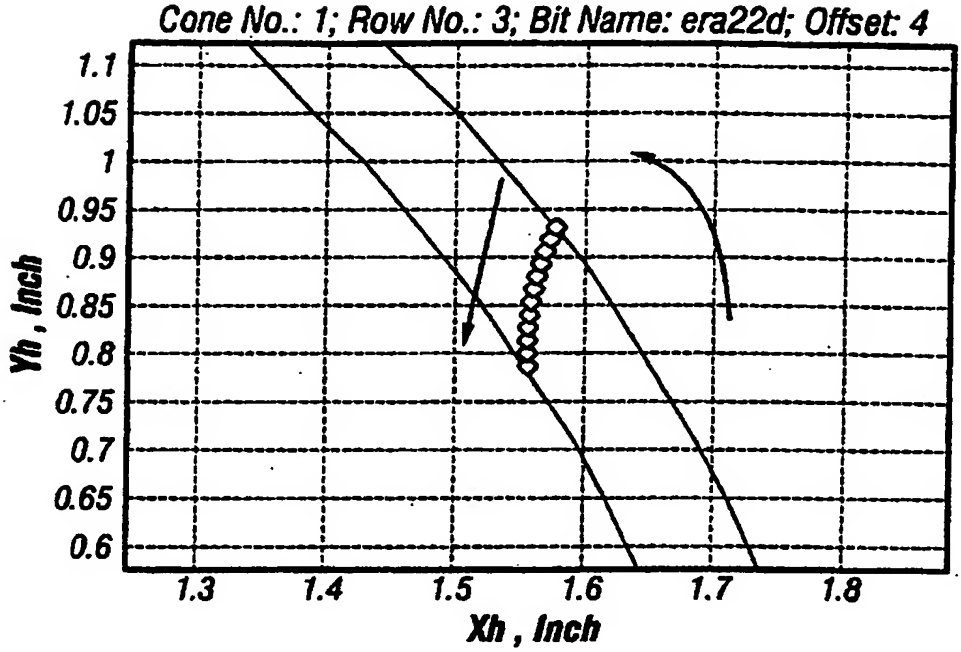
Cone No.: 1; Row No.: 3; Bit Name: era22d; Offset: 4
1.1
1.05
1
0.95
0.9
0.85
0.8
0.75
0.7
0.65
0.6
Yh , Inch
1.3
1.4
1.5
1.6
1.7
1.8
Xh , Inch

FIG. 3C

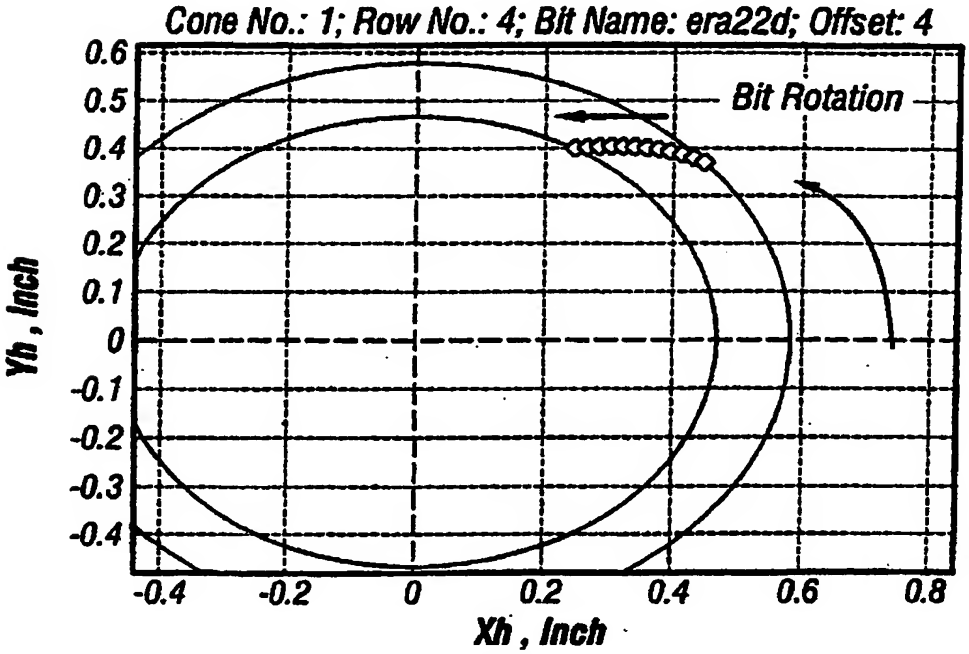
Cone No.: 1; Row No.: 4; Bit Name: era22d; Offset: 4
Bit Rotation
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
Yh , Inch
-0.4
-0.2
0
0.2
0.4
0.6
0.8
Xh , Inch

FIG. 3D

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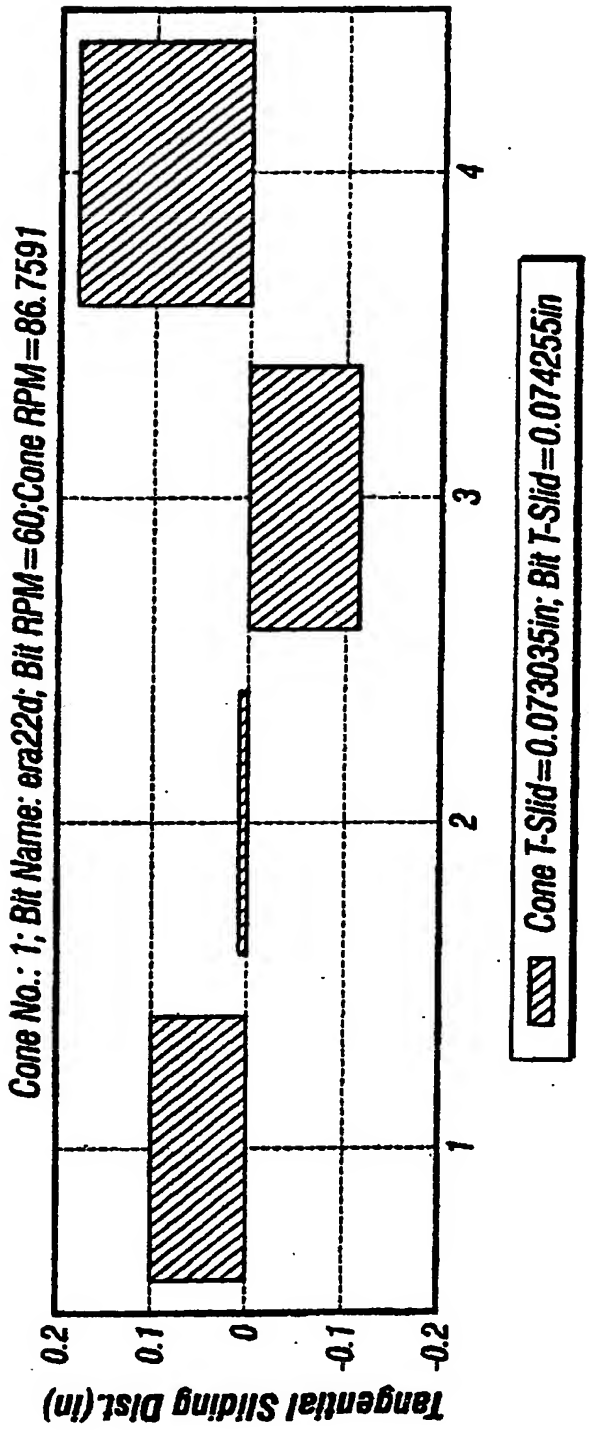
Cone No.: 1; Bit Name: era22d; Bit RPM=60;Cone RPM=86.7591
Tangential Sliding Dist.(in)
0.2
0.1
0
-0.1
-0.2
1
2
3
4
Cone T-Slid=0.073035in; Bit T-Slid=0.074255in

FIG. 4A

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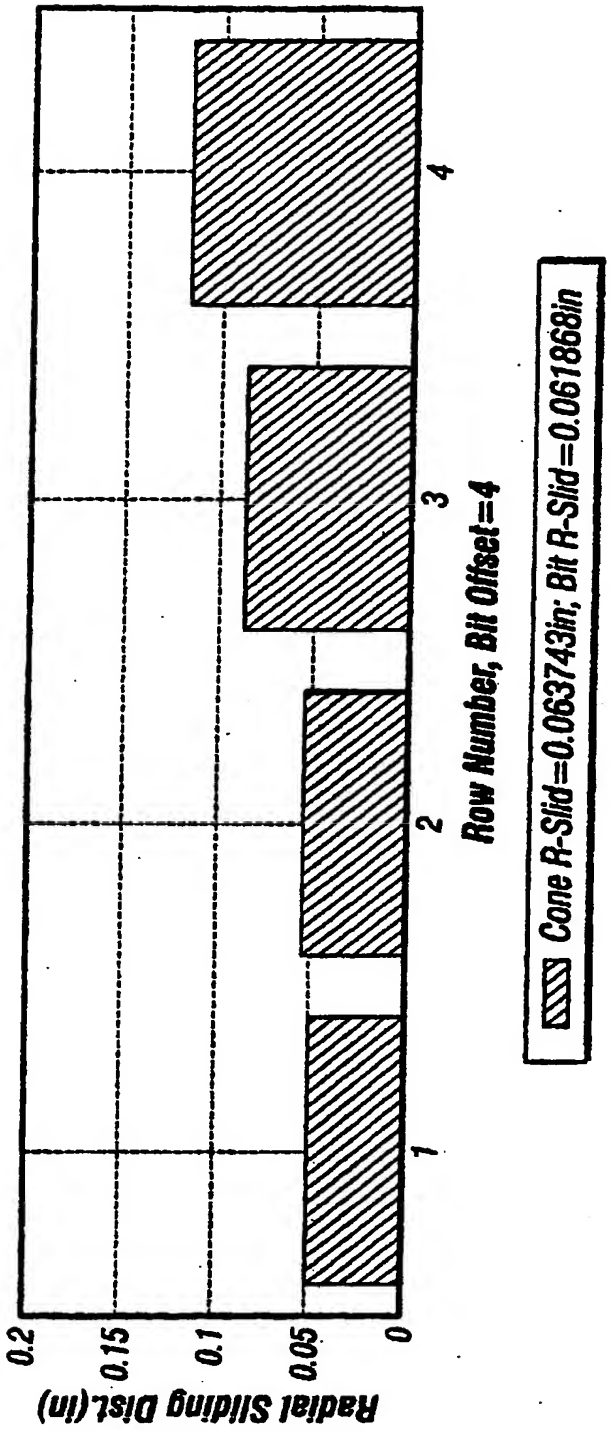
Radial Sliding Dist.(in)
0.2
0.15
0.1
0.05
0
Row Number, Bit Offset=4
1
2
3
4
Cone R-Slid=0.063743in; Bit R-Slid=0.061868in

FIG. 4B

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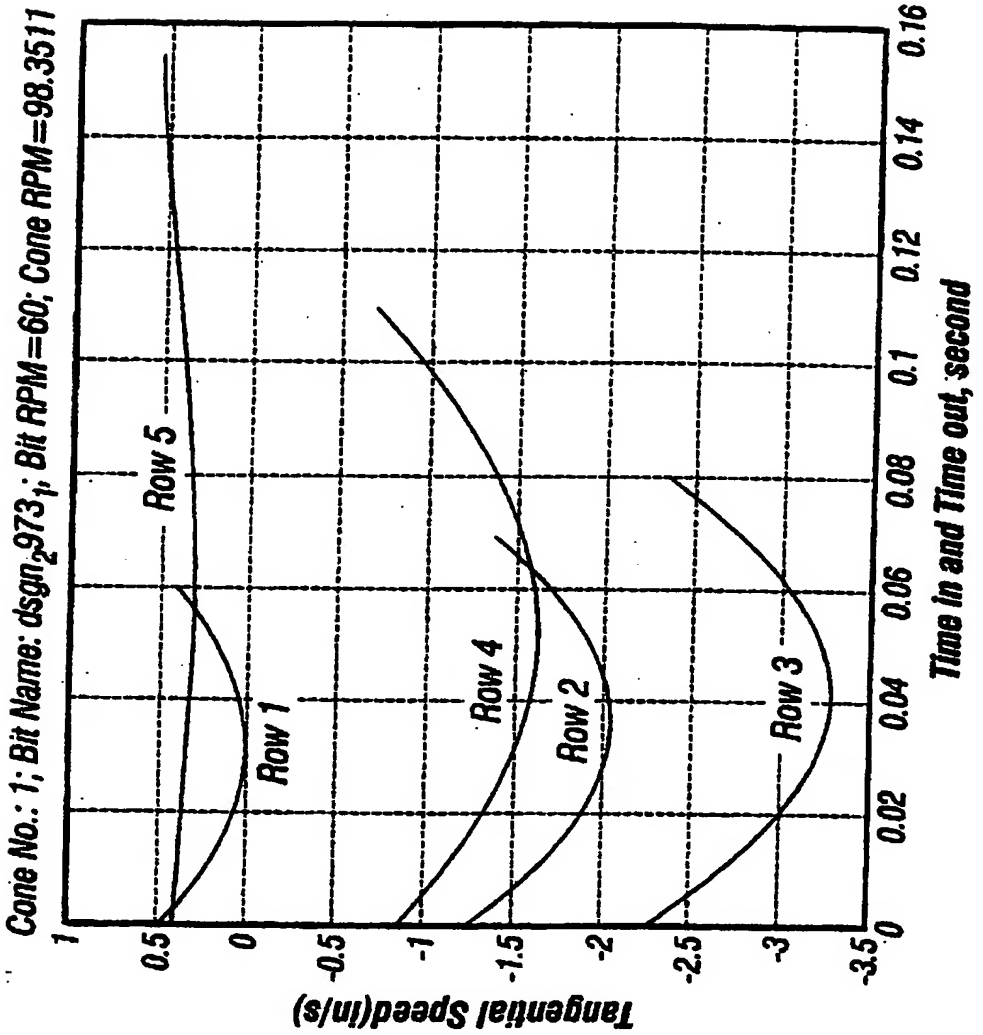
Cone No.: 1; Bit Name: dsgn2973j; Bit RPM=60; Cone RPM=98.3511
Row 5
Row 1
Row 4
Row 2
Row 3
Tangential Speed(in/s)
1
0.5
0
-0.5
-1
-1.5
-2
-2.5
-3
-3.5
0
0.02
0.04
0.06
0.08
0.1
0.12
0.14
0.16
Time in and Time out, second

FIG. 6

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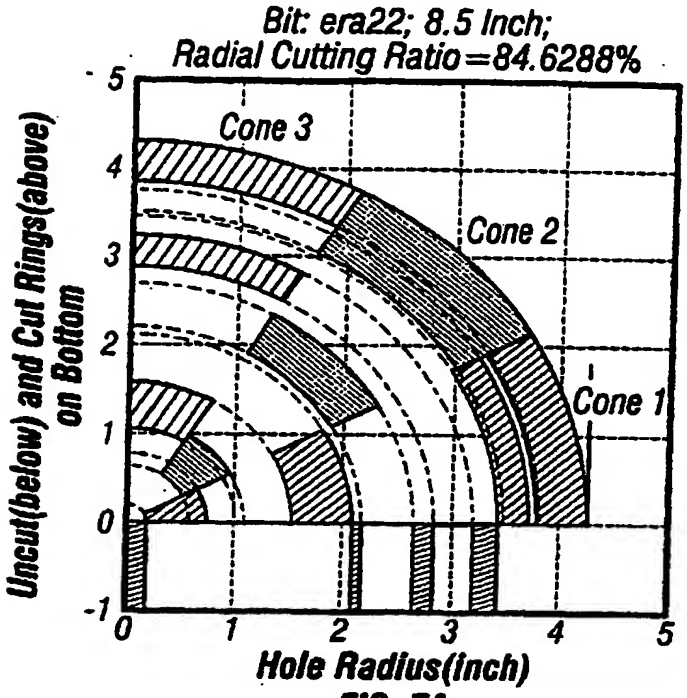

FIG. 7A

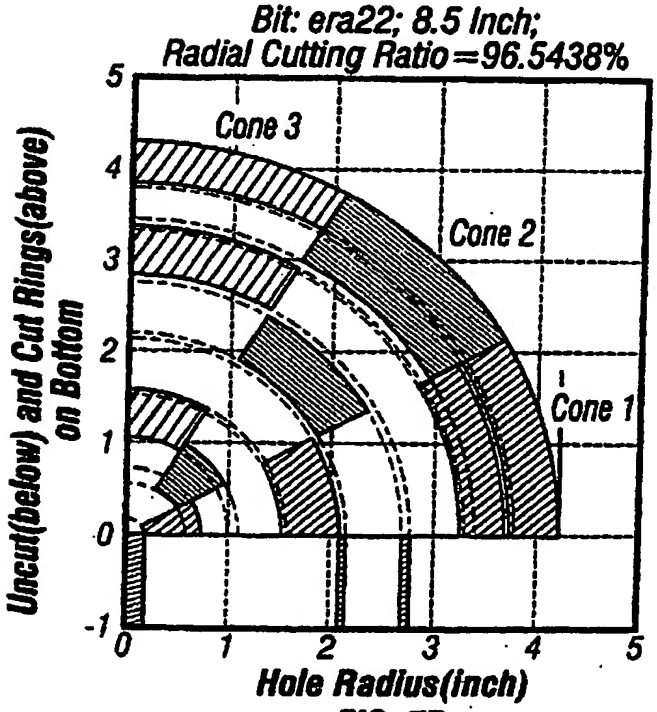

FIG. 7B

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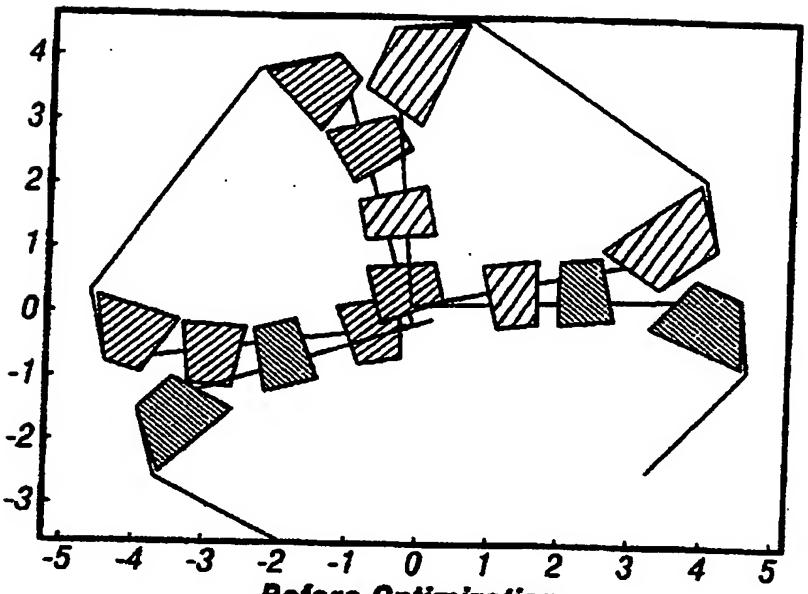
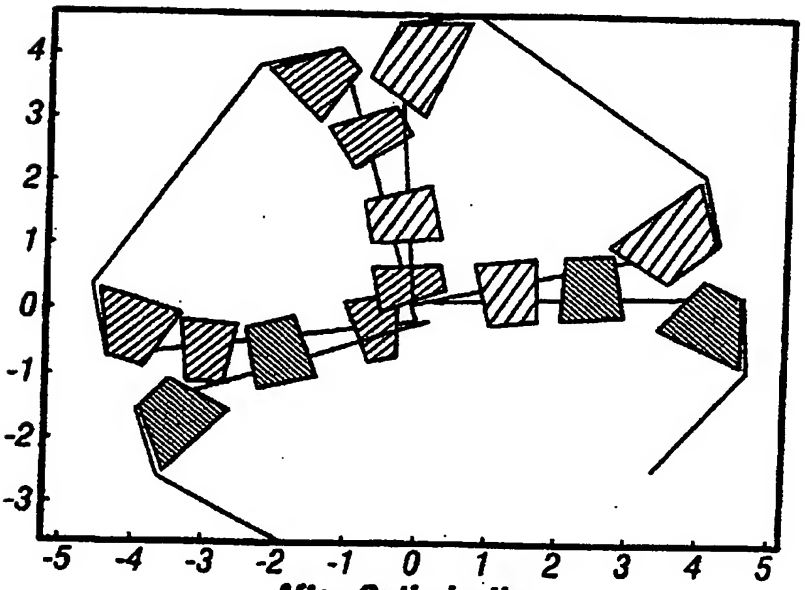


Before Optimization

FIG. 8A



After Optimization

FIG. 8B

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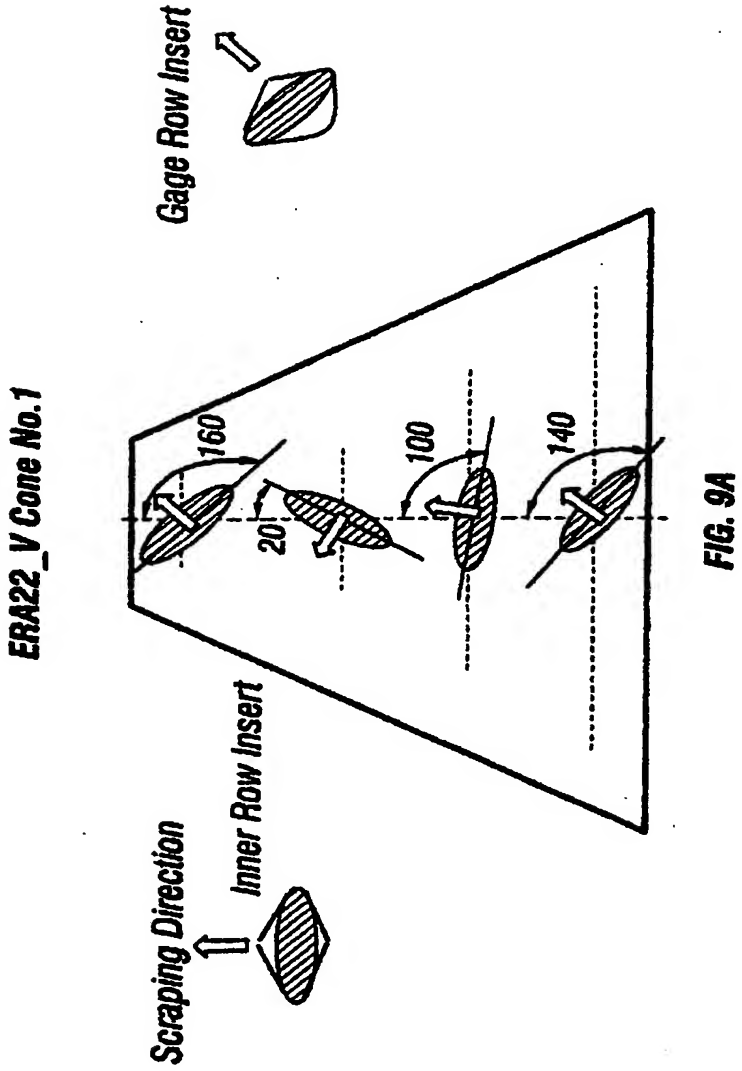
Gage Row Insert
ERA22_V Cone No.1
160
20
100
140
Scraping Direction
Inner Row Insert

FIG. 9A

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ERA22_V Cone No.2

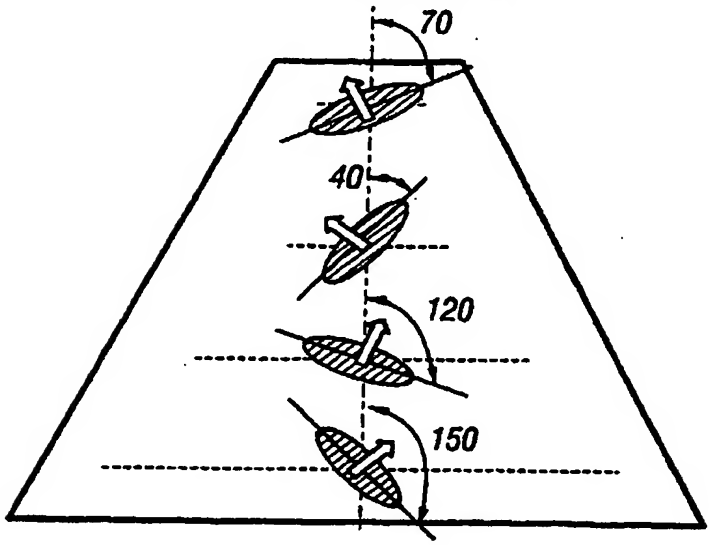

FIG. 9B

ERA22_V Cone No.3

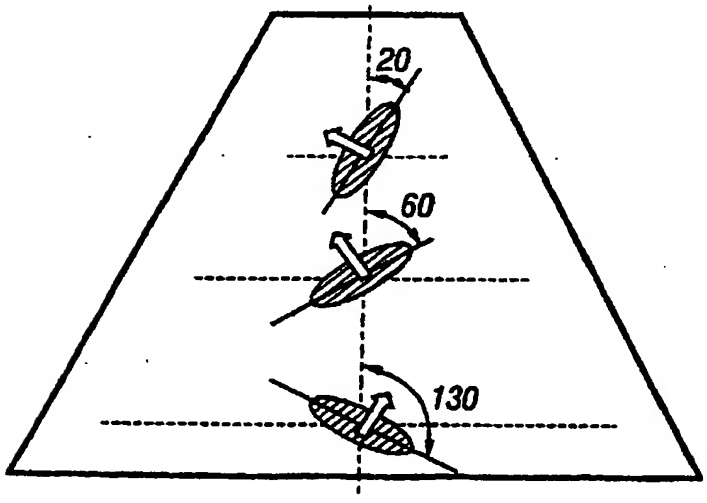

FIG. 9C

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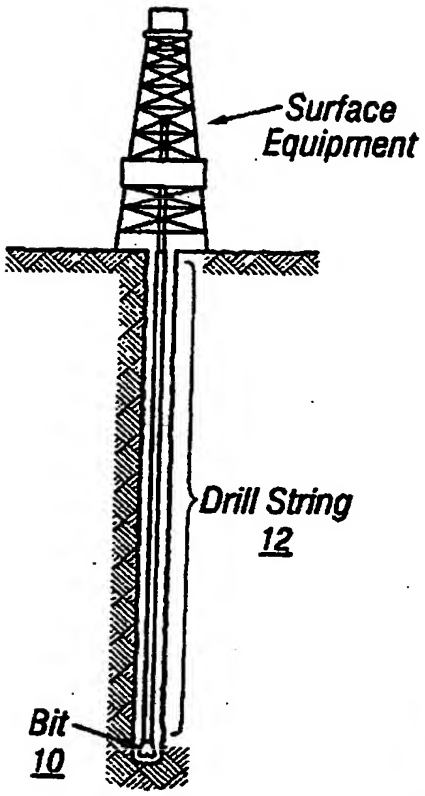

FIG. 10

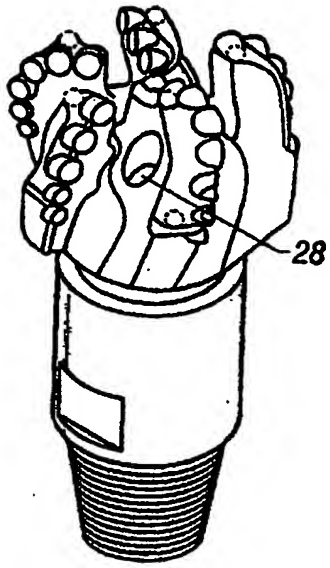

FIG. 11

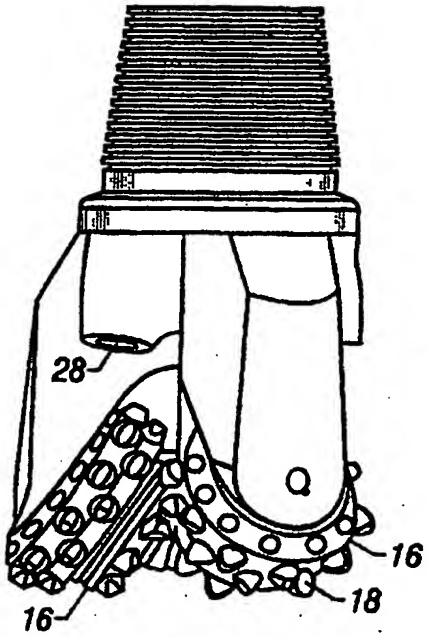

FIG. 12

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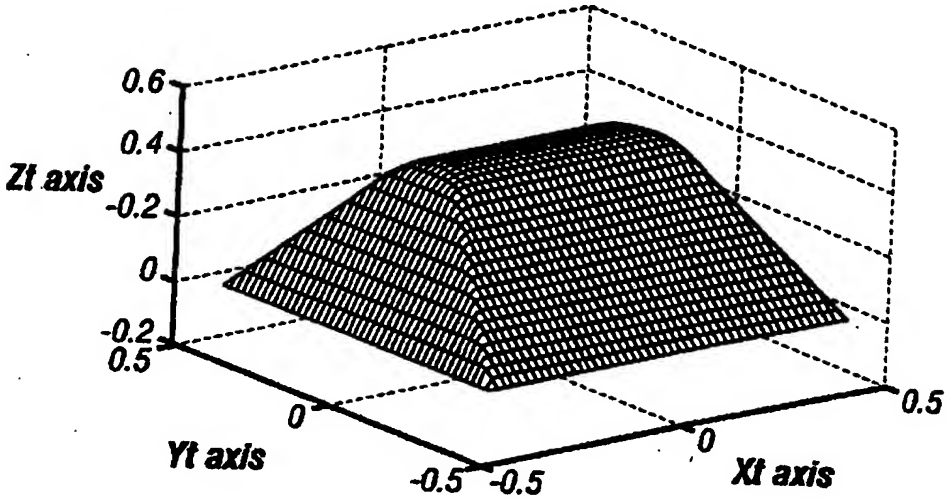

FIG. 13

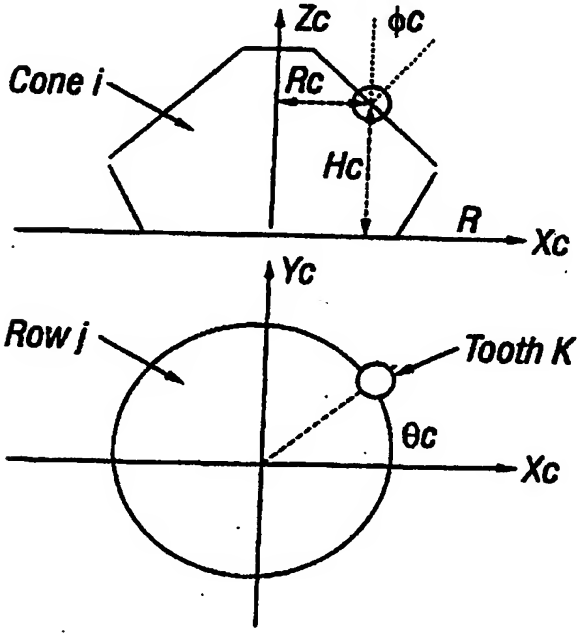

FIG. 14

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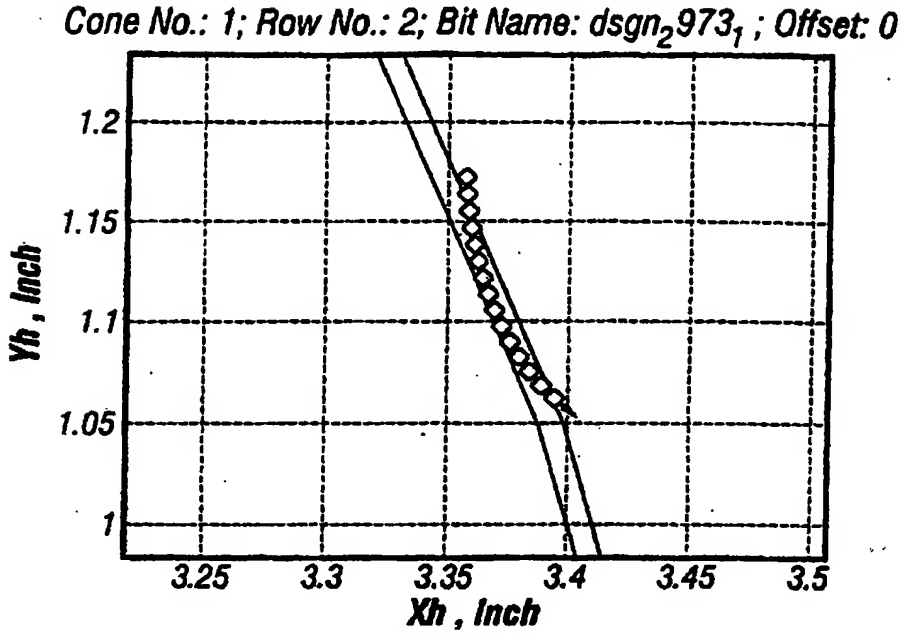

FIG. 15A

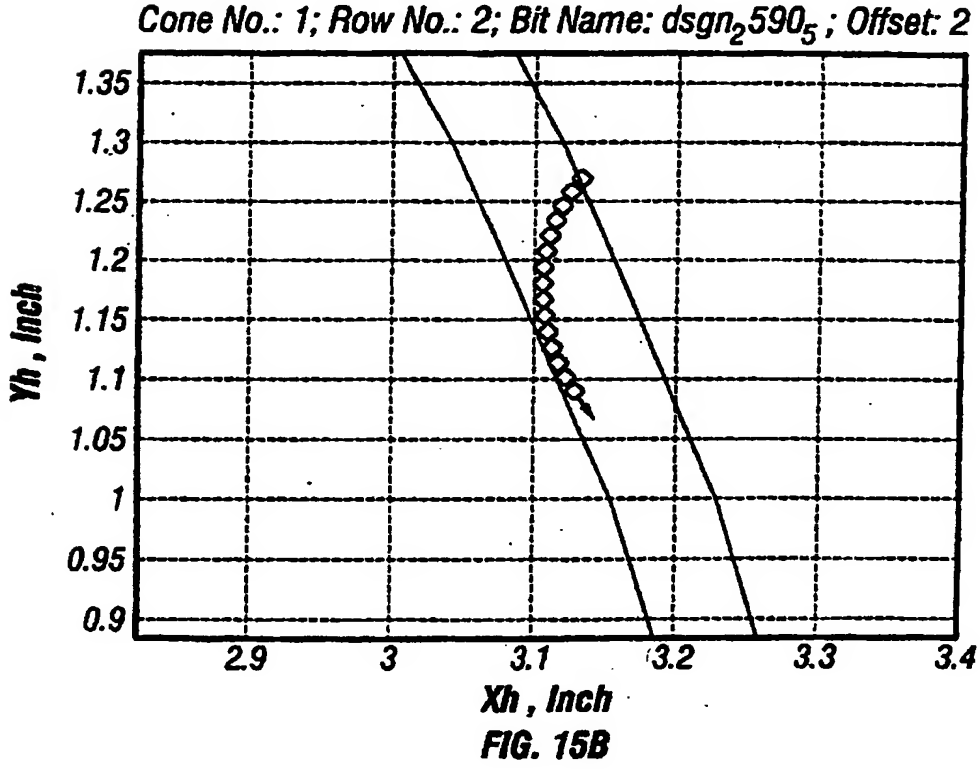

FIG. 15B

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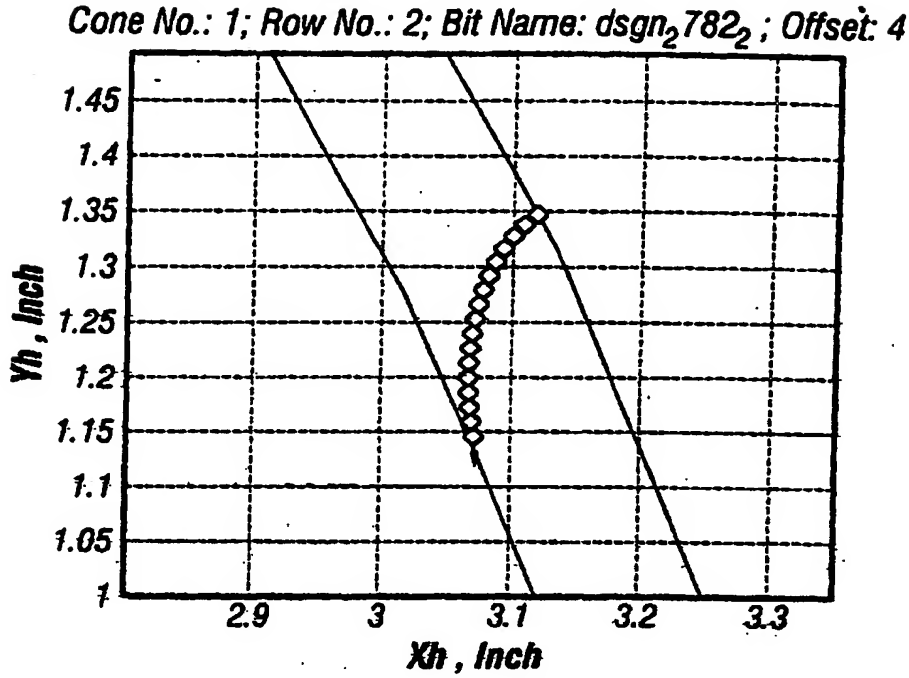

FIG. 15C

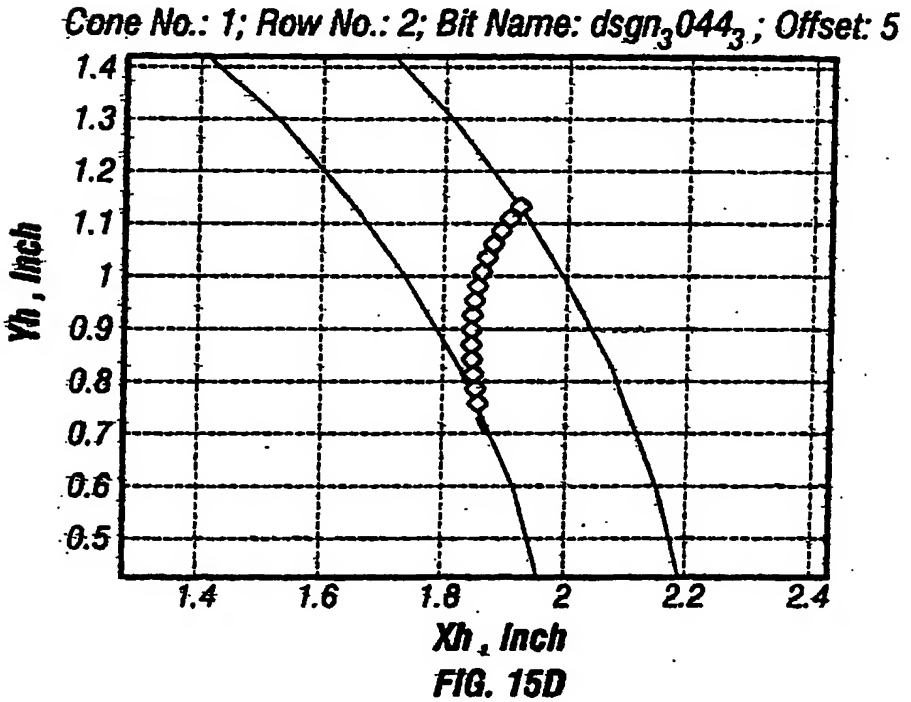

FIG. 15D

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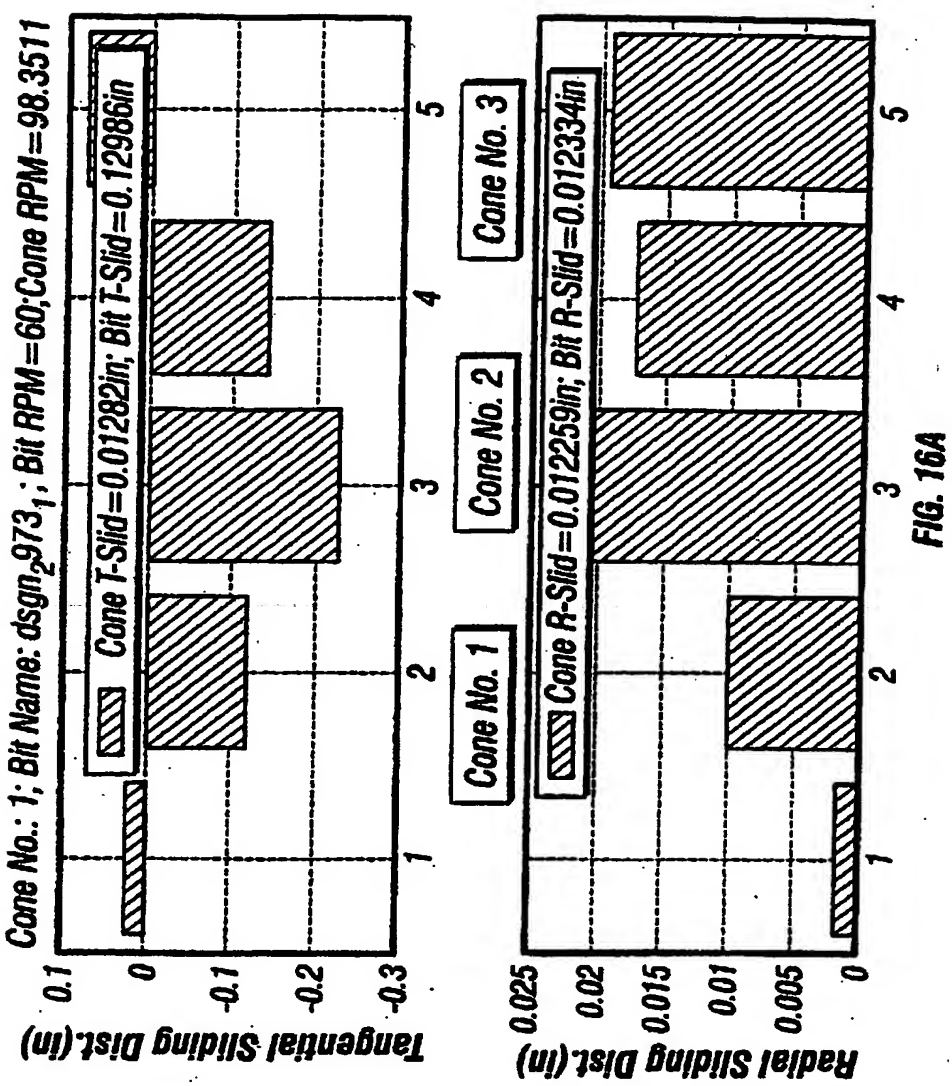
Cone No.: 1; Bit Name: dsgn2973_1; Bit RPM=60;Cone RPM=98.3511
Cone T-Slid=0.01282in; Bit T-Slid=0.12986in
Tangential Sliding Dist.(in)
0.1
0
-0.1
-0.2
-0.3
1
2
3
4
5
Cone No. 1
Cone No. 2
Cone No. 3
Cone R-Slid=0.012259in; Bit R-Slid=0.012334in
Radial Sliding Dist.(in)
0.025
0.02
0.015
0.01
0.005
0

FIG. 16A

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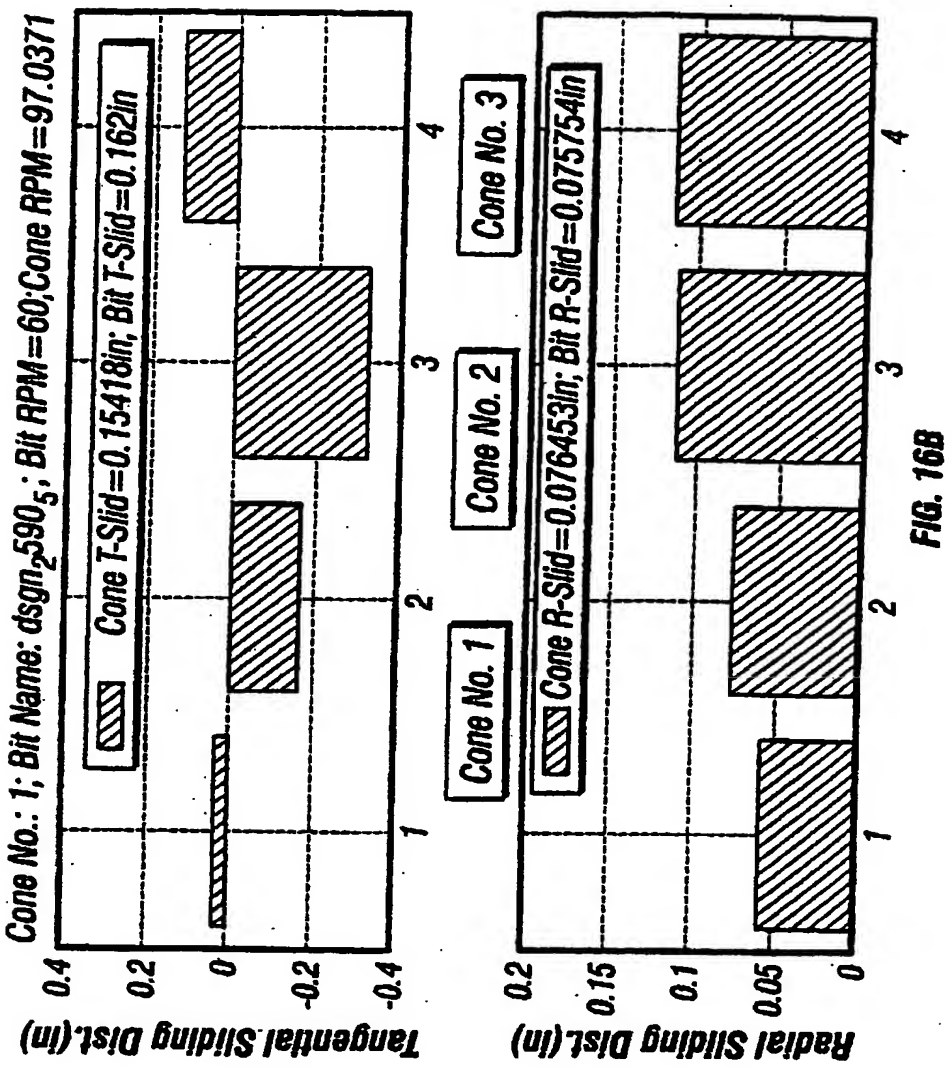
Cone No.: 1; Bit Name: dsgn2590_5; Bit RPM=60;Cone RPM=97.0371
Cone T-Slid=0.15418in; Bit T-Slid=0.162in
Tangential Sliding Dist.(in)
0.4
0.2
0
-0.2
-0.4
1
2
3
4
Cone No. 1
Cone No. 2
Cone No. 3
Cone R-Slid=0.076453in; Bit R-Slid=0.075754in
Radial Sliding Dist.(in)
0.2
0.15
0.1
0.05
0
1
2
3
4

FIG. 16B

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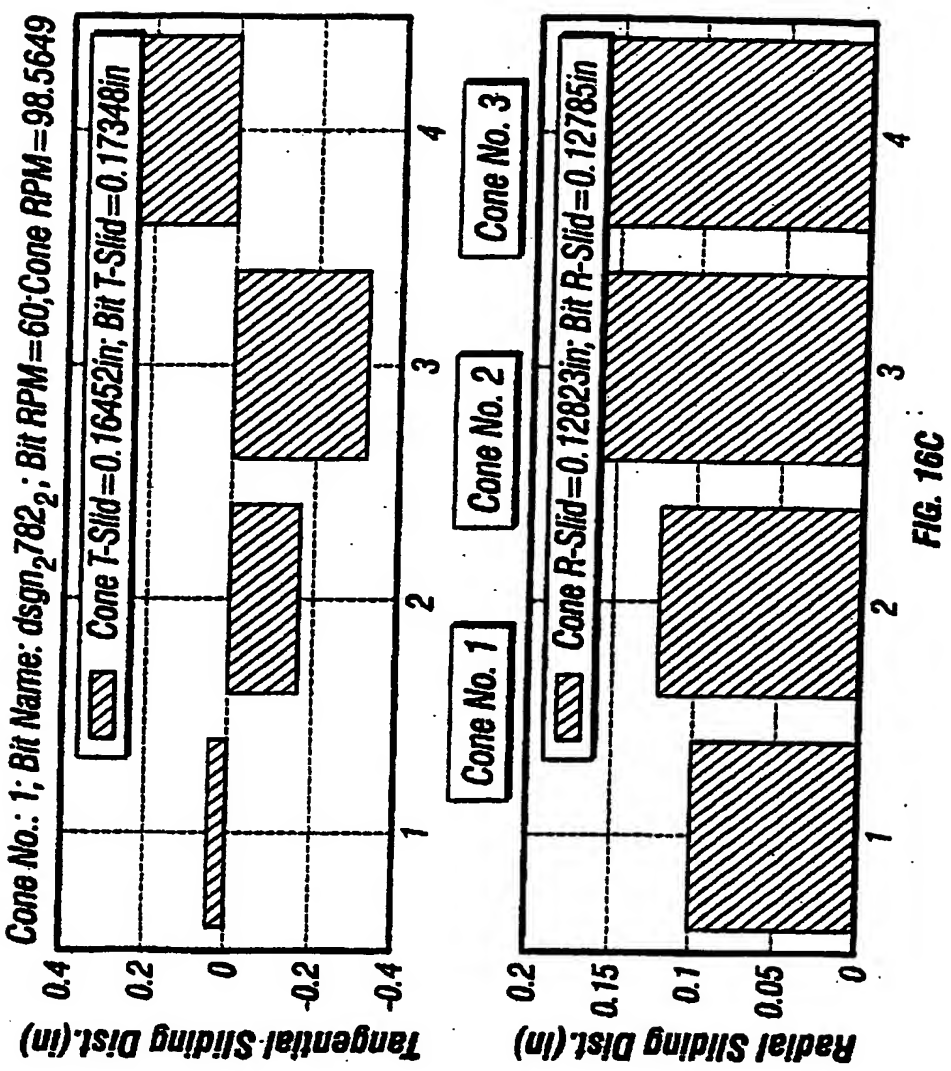
Cone No.: 1; Bit Name: dsgn_2782_2; Bit RPM=60; Cone RPM=98.5649
Cone T-Slid=0.16452in; Bit T-Slid=0.17348in
Tangential-Sliding Dist.(in)
0.4
0.2
0
-0.2
-0.4
1
2
3
4
Cone No. 1
Cone No. 2
Cone No. 3
Cone R-Slid=0.12823in; Bit R-Slid=0.12785in
Radial Sliding Dist.(in)
0.2
0.15
0.1
0.05
0

FIG. 16C

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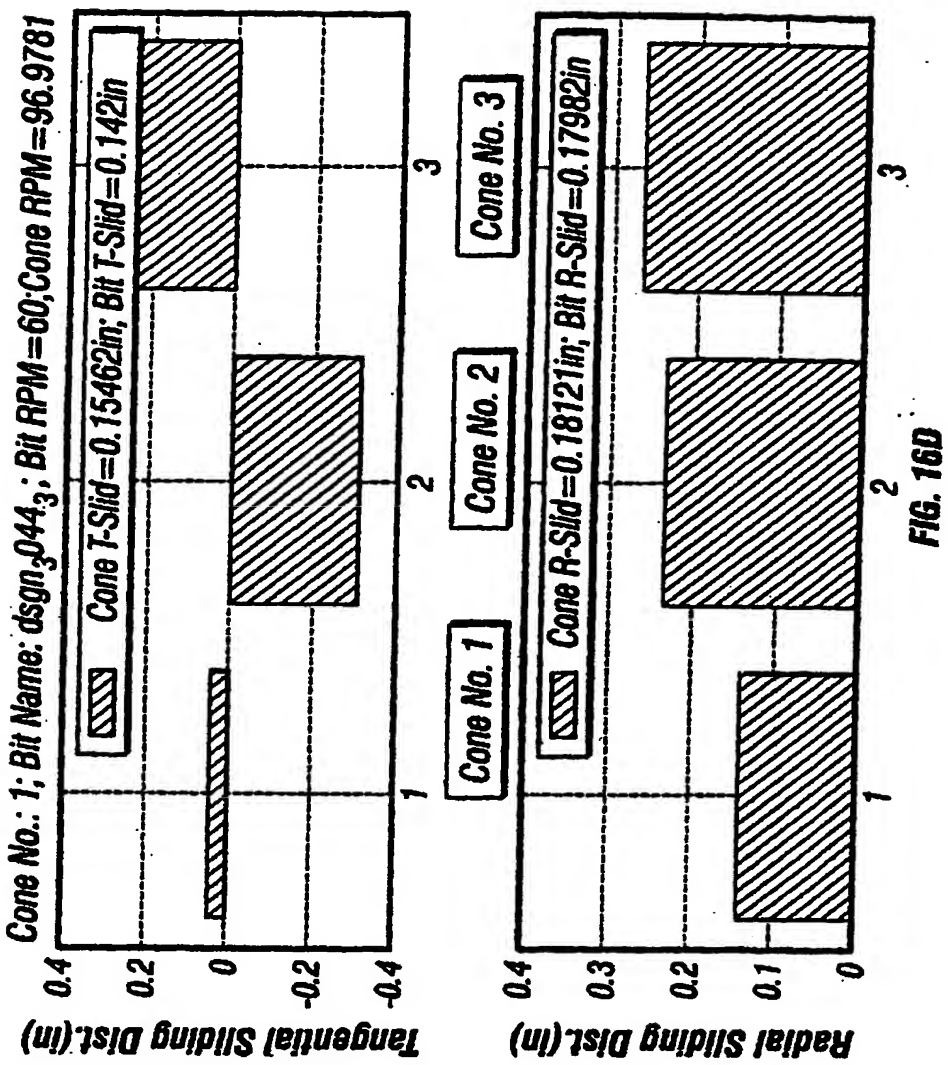
Cone No.: 1; Bit Name: dsgn3044_3; Bit RPM=60;Cone RPM=96.9781
Cone T-Slid=0.15462in; Bit T-Slid=0.142in
Tangential Sliding Dist.(in)
0.4
0.2
0
-0.2
-0.4
1
2
3
Cone No. 1
Cone No. 2
Cone No. 3
Cone R-Slid=0.18121in; Bit R-Slid=0.17982in
Radial Sliding Dist.(in)
0.4
0.3
0.2
0.1
0
1
2
3

FIG. 16D